PUERTO RICO EXPERIMENT STATION
of the
UNITED STATES DEPARTMENT OF AGRICULTURE
MAYAGUEZ, PUERTO RICO

REPORT OF THE PUERTO RICO EXPERIMENT STATION 1942

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PUERTO RICO EXPERIMENT STATION

Administered by the Office of Experiment Stations
Agricultural Research Administration
United States Department of Agriculture
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[1] In cooperation with the Government of Puerto Rico.

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INTRODUCTION

With the advent of the war, the Puerto Rico Experiment Station, like many other Government agencies, shifted most of its program to problems directly concerned with the war effort. Fortunately many of the established projects were of strategic importance, and it was necessary only to expand and strengthen these, temporarily suspending emphasis on the less important. Puerto Rico, being an insular area, has been confronted with various local agricultural problems in the solution of which the station has been able to play an important part, particularly in developing programs for maintaining a sufficient supply of food, a matter of extreme importance in view of the lack of adequate shipping. The need also for many agricultural products used in war activities, heretofore obtained from the Far East, resulted in increasing opportunities for the station to participate in Latin American affairs by providing strategic planting materials and technical assistance in obtaining substitutes, or in actually growing these strategic crops. The station has also been called upon for cooperation with the Army and Navy authorities in planting and camouflage programs.

PERSONNEL

Two members of the staff who had been in Puerto Rico for a number of years resigned to accept positions in the continental United States. Wallace K. Bailey, horticulturist, who had been working

with the station since 1935 on studies of vegetable crops, resigned February 2 to join the Bureau of Plant Industry. James K. Alvis, assistant agricultural engineer, resigned on October 1 and M. Hollis Kannenberg, clerk, on November 10 to join the Soil Conservation Service.

Pedro A. Folch, agricultural engineer, and Antonio R. Villamil, agronomist, employed on the essential-oil project, both under funds provided by the Insular Government, resigned on July 31 and January 4, respectively.

Barton C. Reynolds was appointed assistant agricultural engineer effective April 6 and Dalton W. Miller property clerk on March 24. José E. Natal Colón was appointed agronomist for work on essential-oil crops on January 5 and Jacinto Rivera Pérez as agricultural engineer on the same date, under funds provided by the Government of Puerto Rico.

Personnel of the station engaged in Latin American activities and on leave of absence during the course of the year included the director, Atherton Lee, who spent approximately 6 weeks in July and August in the Dominican Republic completing an agricultural survey for the Brookings Institution. From November 1941 to March 1942 he was on an assignment as assistant director of the agricultural division of the Office of the Coordinator of Inter-American Affairs, from which office he was drafted by the Board of Economic Warfare to serve as technical adviser to the Division of Imports. Arthur G. Kevorkian, assistant plant pathologist and physiologist, was employed by the Government of Ecuador for the entire year, assisting in the organization of an agricultural experiment station.

During the absence of the director in the Dominican Republic, Wallace K. Bailey served as acting director. Kenneth A. Bartlett has been acting director since November.

COOPERATION WITH OTHER GOVERNMENT AGENCIES

The station continued to maintain cordial and cooperative relations with all the other agricultural agencies of the island, both Federal and Insular.

Through funds provided by the Insular Government to the station in the amount of $26,900, studies relating to the agronomy and processing of vanilla, propagation of spices and other tropical crops, propagation and preparation of essential oils, and the propagation and utilization of newly introduced bamboos have been continued. With the aid of these funds the station was enabled to expand its activities, particularly on work of direct benefit to Puerto Rican agriculture.

The Civilian Conservation Corps, administered by the Forest Service, provided men for expansion of the bamboo, mango, and cinchona projects. The National Youth Administration made available a large number of youths who were employed largely in the propagation of plants for distribution to the military authorities for the beautification and camouflaging of new bases.

In cooperation with the Work Projects Administration the station undertook the construction of a water-storage reservoir. Because of other more essential war activities this project had to be discontinued until such time as materials and labor again become available.

The W. P. A. also provided funds for the expansion of the cinchona and the insecticidal-plant programs. The former program was concerned with the production of quinine, an important drug, the supply from the Far East now being cut off. The latter program dealt with the production of rotenone, obtained from various fish-poison plants, and was extremely important to the war effort in view of the nature of this insecticide and the shortage of the more commonly used inorganic insecticides.

The Office of Foreign Agricultural Relations assigned a man, for a period of about 2 months, to work with the station staff on the propagation of insecticidal plants.

The Office of the Coordinator of Inter-American Affairs assigned two men to work at the station, one on the bamboo project in relation to the design and construction of bamboo furniture, and the other on problems connected with the production of local food crops. A specialist in cinchona production from that office visited the station for a number of weeks to familiarize himself with the work under way on the production of this drug crop.

The station continued to provide laboratory space, offices, and field areas for the work of the Soil Conservation Service being carried on in the Mayaguez area. Likewise, office space was provided for the Farm Security Administration, and laboratory and office space for the Bureau of Entomology and Plant Quarantine for studies on the West Indian fruitfly, and for the Insular Government for its inspector of fertilizers and the local plant-quarantine inspector.

Cooperation was extended to the experiment station of the University of Puerto Rico through the provision of office and laboratory space and field areas for experimental work with coffee. Station personnel have also collaborated in experimental work being conducted by this agency.

An excellent spirit of cooperation has been shown by all of the agencies located at the station, and each benefited from the association and work carried on by the others during the year.

Coordination of the agricultural programs being conducted by the various agricultural agencies of the island, both Federal and Insular, has been brought about through the combined efforts of the United States Department of Agriculture Advisory Committee and War Board. In shaping its programs toward the furtherance of the agricultural development of the island and the war effort the station received complete cooperation from all agencies.

DRUG AND SPICE CROPS

Cinchona production: Roy E. Harper.

Three of the four original permanent plantings of *Cinchona* made in Puerto Rico were on clay soils. Those of Maricao and Las Mesas are located on Nipe clay, a ferruginous laterite having somewhat unique characteristics for a clay soil. According to Roberts (*7, pp. 199–201, 475–476*) [1] it contains more than 71 percent of clay in all horizons. It is very low in organic matter, most of this occurring in the top 5 inches. Below this horizon is a layer, in some cases several feet thick, of a very fine, inert material which sometimes dries out to a great depth during the dry season.

[1] Italic numbers in parentheses refer to Literature cited, p. 28.

Since *Cinchona* requires a porous, well-drained soil, Nipe clay seemed to be more suitable for this crop than the other clay soils predominating in the higher mountains of Puerto Rico. Trees planted on this soil survived fairly well and generally made at least 2 years of excellent growth before becoming diseased and unthrifty. Nevertheless, it was found that the root system of *Cinchona* did not develop normally on this soil. The taproot and some of the deeper roots usually became diseased and died. New roots later sprouted from the base of diseased roots, forming a mat of roots near the crown of the tree.

Despite its friability, Nipe clay soil has a very low air capacity and becomes water-logged during the rainy season. This condition would inhibit root development and probably drown some of the deeper roots. Later, during the dry season, the roots do not penetrate deeply enough to obtain sufficient moisture to maintain growth, and the check in growth seems to have a material effect upon the subsequent vigor of the tree. Some of the trees attain a pathological maturity and begin to flower after one or two dry seasons.

Other factors, such as the chemical composition of the soil, may affect development of the root system in *Cinchona*. From chemical analysis of a large number of soils derived from serpentine and related materials, Robinson et al. (*8*, *p. 27*) concluded that the presence of comparatively large quantities of chromium and nickel, and perhaps cobalt, are the dominant causes of infertility in serpentine soils in which the physical conditions are favorable for plant growth.

Certain aberrant types of growth occurring in some of the trees of the Maricao and Las Mesas plantings probably have been caused by nutrient deficiencies or by this mineral toxicity of the soil. The most pronounced of these was a foliar abnormality in which the leaves seemed to stop growing at their margins at an early stage of development. The resultant mature leaves either had an inverted-cup shape or were savoyed in appearance with dark red mottling. Leaves on the fruiting branches differed markedly from the other leaves in that they were much smaller, thick, and flat. The flowers developed only a miniature corolla and were generally sterile, the sterility probably being due to excessive drying of the exposed flower parts.

Two distinct types of chlorophyll deficiency have appeared. One of these was found to be a symptom of iron deficiency. Another pronounced abnormality was one in which many of the leaves developed asymmetrically, one side growing more than the other and causing the midrib to curve. The leaves showed wide diversity in shape and size. The foliage was stained with a light-pink color which predominated over the natural green color in some parts.

Height measurements were made of the 80 trees of the Maricao planting in May 1939, September 1940, and June 1942. Of these trees 35 had lost their terminals prior to the last measurement. The trees made a net gain of 0.76 ± 0.224 foot per annum during the first period and a net gain of only 0.25 ± 0.130 foot per annum during the second period. The remaining 45 trees that had retained their original terminal growing point seemed to fall into 2 classes with regard to the rate of growth. The 21 trees that exceeded 6 feet in height when measured in 1940 grew at the rate of 2.00 ± 0.181 feet annually during the first period, but during the second period growth had receded to a rate of 1.37 ± 0.165 feet. The group of 24 smaller trees grew at about

the same rate for the 2 periods, the growth rate being 1.06 ± 0.226 and 1.12 ± 0.136 feet annually, respectively. *Cinchona* trees are usually felled and the bark harvested for quinine extraction when they begin to grow more slowly. The 21 larger trees above referred to are considered to have reached this stage. These trees, now 9 years old, have an average height of 11.86 feet and an average circumference, 1 foot above the ground, of 8.33 inches.

Cinchona seedlings require very little light at the time of germination and thrive best if given steadily increasing amounts of light as they grow older. When planted under glass-covered frames some difficulty was experienced in adjusting the shade to admit the correct amount of light for the seedlings. Continuous shade throughout the day provided enough light for the first 4 or 5 weeks after germination, but after this period, when more light was needed, an attempt to thin the shade or provide openings to permit the early-morning or late-afternoon sunshine to enter usually caused severe injury to the seedlings, and they then developed a reddish color, ceased growing, and soon died. Less severe injury checked the growth of the plants, and the seedlings thus injured rarely completely recovered and usually succumbed. Examination of many injured seedlings revealed that the root system started dying first and that the top portion of the plant did not die until all of the functioning root system had been lost. It was suspected that a fungus, probably saprophytic, attacked the dying root system of the injured and weakened plants.

Nursery shelters of a design similar to the type commonly used in the East Indies for *Cinchona* seedlings in the early stages of growth were constructed. Each shelter has a roof running east and west, about 7 feet high at the ridge. The south slope spans 7 feet and extends to within 18 inches of the ground, and the north slope spans 2 feet and extends to within 6 feet of the ground. The seedbed, 3 feet wide and 40 or 50 feet long, is located somewhat to the back from the open or north side of the shelter. The amount of indirect light admitted to the seedbed is controlled by placing cloth on the open sides. A large number of seedlings, previously started in pots, were shifted to one of these shelters soon after its completion, and under the new conditions the plants made excellent growth with practically no loss from excess light or damping-off. Of the approximately 8,000 seedlings, 1,000 were transplanted when 5 or 6 months old to nursery beds under this kind of shelter, and 3,500 have been successfully transplanted to open nursery beds provided with fern-leaf shade.

Weather conditions at the Maricao nursery are somewhat adverse for transplanting seedlings to open nursery beds. Temporary fern-leaf shades were provided to shield the beds from direct sunlight and to break the impact of the torrential rains that occur frequently during the spring and summer months. In spite of this, a portion of the freshly transplanted seedlings were usually beaten into the soil by concentrated drippings from the heavy rains. The handling involved in straightening and staking such seedlings often resulted in a leaf infection which eventually killed them. It was found that a mulch of fragmented fern leaves, placed around the seedlings on the surface of the nursery bed immediately after transplanting, prevented them from being beaten into the soil and enabled them to straighten normally after a hard rain. This mulch also prevented excessive drying of the nursery bed after several days of sunny weather. Seedlings

thus treated were observed to recover from the shock of transplanting and to resume growth sooner than those left untreated.

Under Puerto Rican conditions, *Cinchona* has one principal flowering period, generally from May to August. Some trees may flower earlier or later than this, depending upon how rapidly they resume active growth after the beginning of the rainy season. Others, which seem to have reached an advanced stage of maturity, flower more or less continuously throughout the year.

Cinchona has a paniculate type of inflorescence, the numerous flowers of which mature over a period of from 1 to 3 weeks. The flower buds generally open early in the morning but may be delayed by cloudy weather. It was found that anthesis occurs up to 24 hours before the flower buds open.

A type of flower dimorphism occurs in *Cinchona* in which certain trees produce only macrostylous flowers and others only microstylous flowers. The style and stigma of macrostylous flowers are from 10 to 13 millimeters in length, and the stamens extend to but 5 millimeters from the ovary. On the other hand, the style and stigma of microstylous flowers are from 4 to 6 millimeters in length and the stamens extend to 10 or 11 millimeters from the ovary. This physical condition would serve to discourage self-pollination, but a certain amount of it would still be expected if the pollen remains viable until the stigma becomes receptive.

Trees bearing macrostylous flowers occur more abundantly than those bearing microstylous flowers, the proportion being about 2 or 3 to 1. The flowers are visited freely by the honeybee and occasionally by a few other insects, and macrostylous flowers are cross-pollinated readily by this means. It has been observed, however, that in the afternoon of the day of opening of the flowers, when the stigmas of macrostylous flowers have been thoroughly pollinated, the more inaccessible stigmas of microstylous flowers are relatively undisturbed and hold little or no trace of pollen. It is likely that most of the microstylous flowers are pollinated on the day following opening, after the corolla abscises and falls away. The stamens are adnate to the corolla wall, and when the corolla of a macrostylous flower abscises, the stigma is pulled through the ring of anthers contained in the corolla tube. When this occurs a quantity of pollen is left adhering to the stigma, and later visits by bees may carry this pollen to the stigmas of the corollaless microstylous flowers. Sands (*9*) has observed that when all of the trees of a plantation produce either macrostylous or microstylous flowers alone only a few seeds are produced, whereas when the two types occur together in a planting seed production is abundant. However, it is not definitely known whether trees are self-sterile or intersterile with other trees of the same flower type.

The fruit of *Cinchona* is a dry, loculicidal capsule in which the seeds are attached to an axial placenta. Dehiscence occurs by the splitting of the septa, which begins near the base of the fruit, the two carpels remaining united at base and apex. The different species of *Cinchona* vary somewhat in the degree of opening of the carpels and the amount of separation between them. This is due largely to the original shape of the fruit, which may vary from approximately ovoid to ellipsoid. Some strains of *C. officinalis* L. approach the ovoid in fruit form, whereas the ellipsoid is typified in *C. pubescens* Vahl. Other species and hybrids are intermediate between these two in form.

In dehiscence, the carpels of the ovoid capsules are not much changed in shape and they usually open and separate from each other only slightly. This results in their retaining nearly all of their seeds at the time of dehiscence, very few dropping or being blown out by the wind. In the ellipsoid capsule, however, the margins of the carpel readily roll outward on drying, and the flattened carpels separate widely from each other, thus permitting the tiny, winged seeds to be blown out and scattered by the wind.

These morphological differences have practical significance in the collection of seeds. If, within a few days after dehiscence, the fruit clusters of ovoid capsules are carefully detached and bagged, approximately 75 to 95 percent of the seeds may be collected. Since the fruit clusters usually ripen unevenly, 1 week or more often intervening between the dehiscence of the first and the last capsules, they may be collected when nearly all of the cluster is ripe and then stored in a warm, dry place for dehiscence of the remaining capsules. Seeds harvested in this way are in prime condition, and a high percentage of germination results.

If the ellipsoid type of capsule is allowed to ripen and dehisce, the seeds are blown away and lost. In previous work at this station, harvesting the fruits at different stages of maturity before dehiscence, in order to collect the seeds, was tried, and it was found that germination was impaired 73 percent by harvesting red, unopened capsules and drying them in direct sunlight. To remedy this difficulty another method, that of enclosing each fruit cluster in a small bag made of light cheesecloth before beginning of dehiscence, was tried. After dehiscence was complete, the cluster and bag with collected seeds were removed, and seeds collected in this way were found to give excellent germination. A portion of the seeds of each cluster had been exposed to the weather for more than a week, but the bagging material used permitted free circulation of air and exposure to sunlight, which dried the seeds promptly. Marañon and Bartlett (*4, fig. 23*) have reported that a bagging method similar to that described above is used in the Philippine Islands.

Spice Crops: Carmelo Alemar, Jr.

Plantings of various spice crops, particularly nutmeg (*Myristica fragrans* Houtt.), Ceylon cinnamon (*Cinnamomum zeylanicum* Nees.), tonka-bean (*Dipteryx odorata* (Aubl.) Willd.), Malaya cinnamon (*Cinnamomum burmani* Blume), and black pepper (*Piper nigrum* L.) on hillside lands of heavy Catalina clay have made good growth under Mayaguez conditions during the year. These spice crops apparently will become adapted to conditions found in many areas of Puerto Rico, and may prove to be important as substitute crops for coffee.

A quantity of seed of Hungarian paprika (*Capsicum annuum* L.) was obtained from the Division of Plant Exploration and Introduction of the United States Bureau of Plant Industry. The first crop indicated that this plant could be successfully grown in Puerto Rico. Fruits were obtained within 15 weeks after seeding, and, although the plants were comparatively small, fruiting was profuse. Five distinct types of pods were obtained, and selections were made of the various segregations in order to stabilize, if possible, the seed of the strains involved.

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INSECTICIDAL PLANTS

Physiology and Agronomy of Rotenone Crops: Rufus H. Moore and Merriam A. Jones.

Approximately 2 acres of the Sarawak Creeping variety of *Derris elliptica* (Roxb.) Benth. were planted at Caguas on the property of Eastern Sugar Associates, primarily to obtain figures on the cost of production of this crop in Puerto Rico and secondarily to conduct a simple spacing experiment. The field selected was a Toa sandy loam, the surface soil of which was particularly favorable to this crop in that the deep plowing necessary to harvest the roots would not bring the subsoil to the surface. Rainfall during the 26 months of the experiment was fairly evenly distributed and averaged 64.82 inches annually.

Unrooted cuttings 9 inches long and 1 centimeter or more in diameter, planted in 20 replicated plats of approximately 0.03 of an acre each, were spaced 1, 2, and 3 feet apart in rows 3½ feet apart. Three months after planting, a 10–6–16 commercial fertilizer was applied at the rate of 600 pounds per acre, and 5 months later ammonium sulfate was applied at the same rate. In less than 7 months the plants of the 1- and 2-foot spacings had completely covered the soil, while those of the 3-foot spacing had weedy spots not covered by a mat of vines. On an acre basis the average number of cuttings of commercial size harvested was practically the same for all spacings, 15,112, 14,950, and 14,825, respectively. The average weight of the cuttings per acre tended to decrease slightly with increased spacing of the plants.

The spacings used in this experiment had no significant effect on either the yield of air-dry roots or the percentages of rotenone and total extractives. The 1-, 2-, and 3-foot spacings yielded 900, 920, and 885 pounds of air-dry roots per acre, analyzing 6.5, 6.3, and 6.3 percent rotenone, and 21.6, 21.7, and 20.7 percent total extractives, respectively. The average yield of 902 pounds of air-dry roots per acre was somewhat lower than expected and was perhaps due to the use of unrooted rather than rooted cuttings and the resultant competition with weeds while the plants were becoming established. The lack of significant differences in yields was probably associated with the fact that the vines were allowed to trail over the ground. Under this system of culture the competition of the plants for sunlight became practically uniform as soon as the vines had completely covered the soil, thus neutralizing any early advantage due to spacing.

Of $446.47 per acre spent on the planting, weeding, harvesting, and miscellaneous expenses for this experiment, $313.60 was for harvesting the cuttings and roots, and for preparing and planting nurseries for another crop. The cost of weeding amounted to $79.35, which might have been reduced somewhat by closer planting and by using rooted cuttings. The first weeding alone cost $33.28 as compared with an average cost of only $6.59 for the other 7 weedings. A total of 423 man-days per acre was used to grow and harvest the crop, plant the nurseries, and bale the roots obtained.

The influence of diameter of cutting on the yield and quality of derris roots was tested in an experiment with rooted cuttings of *Derris elliptica* var. Sarawak Creeping planted in a field of infertile sandy clay high in iron. Those that had been parent cuttings har-

vested from a former experiment were classed as large, and ranged from 40 to 12 millimeters in diameter. The medium and small cuttings, all of which were made from vines, varied between 15 and 8 millimeters, and 8 and 5 millimeters in diameter, respectively. Nine replicated plats of 0.015 of an acre each were planted to cuttings of each series placed 2 feet apart in rows 3 feet apart. After 3 months the dead or weak plants, most numerous in plats of small cuttings, were replaced. During the 31-month period of the experiment small cuttings had increased so much in thickness that their mean diameter was 12.4 millimeters, the same as that of the medium cuttings. Large cuttings, with a mean diameter at harvest of 20.8 millimeters, had increased only slightly in thickness.

There was a decreasing trend in the yield of air-dry roots of 1,117, 1,094, and 1,010 pounds per acre for large, medium, and small cuttings, respectively, but large standard deviations made this trend nonsignificant. Because of the unusually long growth period the vines of all plats attained complete coverage of the soil long before the experiment was harvested. The resultant equalization of competition of the plants for sunlight tended to equalize the yields of roots, as in the spacing experiment already discussed. Estimates of the content of rotenone and total extractives were made on root samples from each of the 27 plats. On a moisture-free basis the large, medium, and small series yielded 5.0, 5.8, and 5.7 percent of rotenone and 15.2, 17.3, and 17.4 percent of total extractives, respectively. The quality of roots of the medium and small series as compared with roots of the large series was highly significant for both rotenone and total extractives. The slight root-quality differences between the medium and small series were not significant.

Nine clones of *Derris elliptica* var. Changi No. 3 were increased by budding onto well-established plants of the Sarawak Creeping and St. Croix varieties of the same species. To expedite the development of vines for cutting material, the area used for propagation was trellised. A total of 919 buds transferred from the Changi No. 3 clones had begun to grow by the end of the fiscal year. On a moisture-free basis, roots from vigorous, trellised plants, 18 months old, of 4 of these clones ranged from 5.5 to 10.4 percent in rotenone content and from 13.3 to 22.8 percent in total extractives. Analysis showed wide variation in roots from different plants of the same clone.

Of the 88 parent plants of *Lonchocarpus chrysophyllus* Kleinh. originally included in clonal studies of this species, 7 were selected as superior on the basis of the germinating capacity of the cuttings and the yield and quality of roots at 27 months of age. After a growth period of 48 months, all progeny plants of the 7 clones were harvested and the roots analyzed. These plants produced an average of 498.1 grams of air-dry roots each, containing 5.0 percent of rotenone and 7.4 percent of total extractives. The greater age of the progeny plants was associated with a mean 84-percent increase in yield of roots, a mean 24-percent decrease in rotenone content, and a mean 38-percent decrease in total extractives content, as compared with corresponding means of the 7 parent plants. Inasmuch as roots increase in size and decrease in quality with age, such trends are generally to be expected. The greater decrease in total extractives as compared with rotenone may have some physiological significance.

Wide plant-to-plant variations in yield of roots and percentages of rotenone and total extractives content were found among the individuals of each clone. While the roots of most of the progeny plants analyzed lower than their parents, in 19 of 82 cases the progeny plants were higher in rotenone than the parents.

The countries of the Far East have been the principal sources of supply of rotenone. The loss of these areas and the great demand for organic insecticides have made apparent the immediate need for increasing the acreage of rotenone-producing plants in the Western Hemisphere. The station probably has the largest supply of planting material of high-rotenone content anywhere available. It was, therefore, highly important to expand the planting program as rapidly as possible in order that maximum quantities of cuttings might be on hand for immediate use. At the end of the fiscal year approximately 300,000 cuttings, mostly of the Sarawak Creeping variety, with relatively few of Changi No 3, were planted in nursery beds. An estimated 5 percent of this number were 8 millimeters or more in diameter; the remaining 95 percent were stems from 3 to 8 millimeters thick, ordinarily considered small for commercial use but which, after 6 months to a year in the ground, should provide good planting stock. During the year 18,000 rooted cuttings and 43,000 unrooted cuttings were distributed for planting in Puerto Rico and 26,415 unrooted cuttings were shipped to Haiti, El Salvador, and Ecuador.

Cuttings of *Derris elliptica* var. Sarawak Creeping provided by this experiment station were planted by the Haitian Government on Plaine Cul-de-Sac near Damien. Plants were spaced 4 by 4 feet, allowed to climb on poles, and given 2 applications of farm manure and 2 of ammonium sulfate. They were irrigated once or twice weekly and received an average annual rainfall of 42.58 inches during the 26 months of growth. Only 71 of the 159 plants reached maturity, a survival of 44 percent. Air-dry roots smaller than 13 millimeters in diameter yielded 5.9 percent of rotenone, and those larger yielded 2.8 percent.

VEGETABLE CROPS

Field Studies: Wallace K. Bailey.

The work on vegetable crops was confined largely to increasing new and selected varieties of corn, soybeans, and yams. In conjunction with the Work Projects Administration, considerable emphasis was placed during the latter half of the year on the production of seed for future planting as part of the food-production program of that agency. A total of 647 pounds of seed of an edible soybean (*Soja max* (L.) Piper) was supplied to the W. P. A., and 1,440 pounds of seed of the U. S. D. A.–34 variety of sweet corn was made available to that agency and to interested farmers throughout the island.

Within the last 20 years soybean culture has assumed vast importance in the United States. Although the station's exhibit of soybeans won the grand premium awarded by the Puerto Rico Fair in 1919, only in recent years have edible soybeans received the consideration that this highly nutritious food crop deserves. Several edible varieties have been tried at the station during the past 6 years, and two of these have been found to thrive particularly well under local conditions, one an unnamed variety and the other the Seminole, introduced by the Bureau of Plant Industry from China in 1931. Under Mayaguez conditions the latter variety required about 130 days from seeding to

maturity and produced a good crop of dry beans, and in most parts of Puerto Rico it should be possible to obtain two crops a year. This soybean has been accepted readily as a green bean for food by practically everyone who has tried it, and it should prove an excellent and desirable substitute or complementary bean for the commonly used gandule.

PLANT INTRODUCTIONS

Field Studies: Claud L. Horn.

Considerably fewer new species of plants were introduced during the year, largely because of the curtailment of transportation facilities throughout the world, many of the sources from which plant material was ordinarily received being entirely cut off. A total of 119 species was introduced, the majority of which were of an ornamental nature.

In plant-introduction work, lists of ornamental plants can always be extended more easily than those of plants of economic value. The former almost always come along with the more desirable economic species whether ornamentals are desired or not. However, in Puerto Rico the extension of ornamental plantings throughout the island has been an important part of the tourist program undertaken in recent years. Another, and perhaps more direct commercial value, lies in supplying such species to Puerto Rican nurserymen for intensive propagation for the florist trade on the mainland. Frequent requests for such plants are received, and in this way the 12-month growing temperature of the island is turned into an appreciable asset.

The Division of Plant Exploration and Introduction of the Bureau of Plant Industry sent to the station an interesting lot of sample fruit plants consisting of 10 species and varieties of the raspberry and blackberry genus, *Rubus*. Additional planting material of a fruit tree, the Philippine mabola persimmon (*Diospyros discolor* Willd.) was received from the same agency. While this species has been represented in the plant-introduction gardens for many years by a well-formed vigorous tree, it has been impossible to propagate it rapidly, for it is the uncommon form with fruits almost always seedless.

Sapucaia nuts, produced by trees of the genus *Lecythis* commonly called monkeypot trees, are among the most delicious of nuts, comparing favorably with the Brazil nut, which belongs to this group. A tree of *Lecythis usitata* Miers, introduced from Brazil by the station some 20 years ago, has thrived and flowered profusely, but none of the flowers have ever developed into fruit. Within recent years plants of *Lecythis elliptica* H. B. & K. from Colombia were introduced, and this year an 8-year-old tree flowered and bore its first fruit. During the past year seeds of *Lecythis zabucajo* Aubl., probably the most important sapucaia nut species, were obtained from Brazil through the Office of Foreign Agricultural Relations, and a few of them have germinated.

Another introduction, both economic and ornamental, was an additional species of rattan palm, *Calamus ornatus* Blume, collected in the Philippine Islands by the Archbold-Fairchild expedition and received through the Division of Plant Exploration and Introduction of the Bureau of Plant Industry. The stem of this palm is said to become some 300 feet long.

One of the essential war materials used extensively in medicine, the leaves of the senna (*Cassia angustifolia* Vahl.), has been imported

into the United States in large quantities from Arabia and the warm parts of Asia. A commercial user of this plant in the United States sent seeds, assumed to be of this species, to the station for trial. Several species of the genus *Cassia* do well in Puerto Rico, and it is possible that this accession will be suited to some of the drier parts of the island.

The propagation and distribution of both introduced ornamental and economic plants received a tremendous stimulus during the year. In cooperation with the National Youth Administration some 50 youths were employed continuously on the plant-propagation project, preparing potted plants for eventual planting at military and naval bases. With the advent of war, not only has the problem become one of ornamentation, but also the need for plants for camouflage work has assumed even greater importance. In addition to actually providing the plant material, the station rendered considerable assistance in working out planting plans and making recommendations for the type of plantings most suitable to the areas and for the type of camouflage desired. During the course of the year some 117,537 plants were distributed for these purposes. In addition, the usual distribution of plants to private individuals for trial was continued, and large numbers were utilized by the various low-cost-housing authorities for projects throughout the island. Propagating material of several plant species was supplied also to individuals and governments in Costa Rica, Cuba, Dominican Republic, Guatemala, Haiti, Hawaiian Islands, Peru, San Salvador, and the Virgin Islands. A total of 354,590 plants and cuttings and considerable quantities of seed and sod grass were distributed during the year.

Rubber Studies: Claud L. Horn and Barton C. Reynolds.

Four species of rubber-yielding plants growing in Puerto Rico were investigated. Introductions of the genus *Castilla* were made many years ago, and ornamental plantings are to be found in various locations throughout the island.

To test the possibility of using 1-year-old seedlings of *Castilla elastica* Cerv. as a quick source of rubber, samples for analysis were prepared by passing the stems and leaves of 1-year-old plants through an experimental sugar mill, the expressed juices being canned and the bagasses dried and baled. The material was sent to a laboratory of the Bureau of Plant Industry in Florida, but in all of the experiments carried out thus far the rubber content has been found to be low.

In addition to *Castilla*, the three following species were similarly tested: *Cryptostegia madagascariensis* Boj., an ornamental vine occasionally grown in Puerto Rican gardens and wild in some parts of the island; *Lanugia latifolia* N. E. Brown, introduced at the station many years ago as a rubber-producing tree but found only in the station plant-introduction gardens; and *Forsteronia corymbosa* (Jacq.) G. F. W. Meyer (*F. floribunda* Cook and Collins), found quite well distributed in the mountains of the island at about 1,000-foot elevations. In all three species the rubber content was found to be low.

ENTOMOLOGY

General Investigations: Harold K. Plank.

In 1940, Bailey (*1*) reported the results of experiments in the control of the corn-silk fly (*Euxesta stigmatias* (Loew)), the corn earworm (*Heliothis armigera* (Hbn.)), and the fall armyworm (*La-*

phygma frugiperda (A. & S.)) in ears of U. S. D. A.–34 sweet corn. White mineral oil of the type used for medicinal purposes injected with a medicine dropper into the tips of the ears at the time the silks began to dry produced satisfactory control of the corn earworm and the fall armyworm, but failed to control the larvae of the corn-silk fly except when the oil contained pyrethrum extract. The development on the mainland of a special type of injector [2] and the successful substitution of dichloroethyl ether for pyrethrins in the mineral oil for corn earworm control (*5*) made it desirable to test this material applied with the new injector in the control of the above three corn-ear pests under local conditions. Such tests were carried out in December by the writer in conjunction with Wallace K. Bailey, horticulturist of the station.

Nine treatments were used, the control and 1 and 2 applications of mineral oil alone and of mineral oil containing 2, 4, and 6 percent by volume, respectively, of dichloroethyl ether. Each of the treatments was applied to a total of 140 ears of U. S. D. A.–34 sweet corn distributed over the field in 28 replicated plats of 5 ears each. All treated ears received the first application when the silks began to wilt and dry, those ears receiving 2 applications being given the second application 5 days later. Eleven days after the first application the tip of each ear was examined for living larvae. All of the untreated ears were found to be infested by either larvae of the corn-silk fly or corn earworms and fall armyworms, and most of the untreated ears contained many larvae of both types of insects. While the new injector was satisfactory, none of the treatments used was effective in controlling the corn-silk fly or in preventing infestation by all 3 insects. In the case of the worms, consistently increasing control was obtained by increasing strengths of dichloroethyl ether, but the only treatments that could be considered to have approached commercial control were 2 applications of the 4- and 6-percent strengths of dichloroethyl ether, and at these strengths this chemical caused considerable injury. When 2 applications of the 6-percent strength were used, not only were the husks on many of the ears severely burned but in some cases the tip of the cob also was so injured that these parts began to rot.

During September and October the pineapple mealybug (*Pseudococcus brevipes* (Ckll.)) was found infesting a planting of the Seminole variety of soybeans. Large colonies of mealybugs had developed about the crown of the majority of the plants, some colonies extending on the roots to about 6 inches below the ground and around the nodes of the stem to about 2 feet above ground. All of these colonies were attended by numerous fire ants (*Solenopsis geminata* (F.)), which in many cases had built nests nearby or about the bases of the infested plants themselves.

Since ants are definitely known to increase pineapple mealybug infestations (*6*), an experiment was conducted in January on the Bansei variety in another field in an effort to forestall infestation by spraying the bases of the plants with a crude carbolic acid emulsion. Approximately one-half of the plants, then about 1 month old from seeding, were already infested with colonies containing nearly mature mealybugs but no eggs or young. Ants were present in many of these

[2] Barber, G. W. THE USE OF OIL FOR EARWORM CONTROL IN SWEET CORN. U. S. Bur. Ent. and Plant Quar. E–476, 6 pp., illus. 1939. [Processed.]

colonies. The spray formula used, a slight modification of that developed in 1911 by Tower (*10, p. 31*), was as follows: Water 1 quart, laundry soap (hard) ½ pound, and crude carbolic acid (100-percent dark) 1 pint. After the soap was dissolved in the water by heating, the crude carbolic acid was stirred into the mixture and sufficient water added to bring the total volume up to 2 quarts. Of this stock 1 pint was further diluted with water to make 6 gallons of completed spray ready for application. Enough emulsion was applied to puddle the soil around the crown and upper roots, and any colonies of mealybugs or ants encountered were thoroughly wet with the spray. Two rows were treated, while another two rows, adjacent, were left untreated. Among both the treated and untreated plants, infestation by the mealybug was light on a relatively large percentage of plants and heavy on comparatively few. None of the light infestations were attended by ants, but some of the heavy infestations were. The treatment had little beneficial effect where no ants were in attendance, but reduced by 77 percent the number of heavy infestations on which ants were present. Although actual control of the mealybug was low, the results of this single application suggest the possibility of keeping heavy infestations at a minimum through the control of the attendant ants.

In addition, a number of other economic insects were observed during the year, and new hosts recorded. The soybean is a new host among the many recorded for the pineapple mealybug in Puerto Rico (*6*).

A fulgorid, *Ormenis pigmaea* (F.), attacked the branches and leaves of the orange-glowvine (*Senecio confusus* Britten) and the Azores jasmine (*Jasminum azoricum* L.) in considerable numbers during the winter and spring. Besides the stunting and killing back of some branches on both species, there was extensive spotting or blotching of the leaves with sooty mold.

Adults of the botrichid *Apate francisca* F. were found boring into and killing 1-year-old cola (*Cola acuminata* Schott and Endl.) trees in the station planting at Las Ochenta in February.

Larvae of the lesser cornstalk borer (*Elasmopalpus lignosellus* (Zell.)) hollowed out the stems of most of the seedlings in a large planting of velvetbeans at Borinquen Field in April.

From the results obtained with a method for controlling dry-wood termites, described in the 1941 report, it was inferred that the common dry-wood or "powder-post" termite (*Kalotermes* (*Cryptotermes*) *brevis* (Walker)) was the only species involved. Collections of swarming adults made during the winter and spring of 1942 in one of the residences treated revealed that two more species were also present, namely, *K.* (*C.*) *cavifrons* (Banks) and *K.* (*Kalotermes*) *snyderi* Light. The former was taken previously by the writer in Mayaguez, in 1936, at which time T. E. Snyder of the Bureau of Entomology and Plant Quarantine, who determined the material, commented that the collection of *K.* (*C.*) *cavifrons* was a new record.

Collections made at lights at two places during the past 6 years have shown that the three species swarm at somewhat different periods. While a few adults of *K.* (*C.*) *brevis* were taken in January and February, this species usually swarmed in April and May. *K.* (*C.*) *cavifrons* was taken also in January and February, but occurred in greatest numbers in March. *K.* (*K.*) *snyderi* swarmed in early May.

In accordance with Insular Plant Quarantine Law No. 35, all plants introduced by the station have been held in the station quarantine house for a period of not less than 6 months in order to observe and eradicate any insects or plant diseases that might be present. During the year, 681 plants of 63 species were thus held, and 71 plants of 23 species received during the previous fiscal year and 22 plants of 8 species received during the present fiscal year were released. The remainder were still held in quarantine at the end of the year because of pests believed to be prejudicial or for fulfillment of the quarantine period.

Biological Control Activities: Kenneth A. Bartlett.

Introductions of two new parasite species, identified as *Hyalomya chilensis* Macq.[3] and *Acaulona peruviana* Towns.[3], which attack cotton stainers (*Dysdercus* spp.), were made from Peru through the cooperation of the Bureau of Entomology and Plant Quarantine. These fly parasites were reared from a cotton stainer identified as *Dysdercus ruficollis* (L.).[4] In Puerto Rico there are known to be two species of *Dysdercus*, one, *D. andreae* (L.), commonly found on cotton and the other, *D. sanguinarius* Stål, only a minor pest of cotton but very common on a native plant, *Thespesia populnea* (L.) Soland, on the south coast.

Three shipments of adults were made, and of 460 *Acaulona peruviana* sent, 161 reached Puerto Rico alive; of 431 *Hyalomya chilensis*, 118 were alive on arrival. Seven shipments were made in the pupal stage, and from 1,670 puparia there emerged 981 *A. peruviana* and 114 *H. chilensis*. Two of the pupal-stage shipments of *A. peruviana* were sent by H. L. Parker of the Bureau of Entomology and Plant Quarantine, who reared the material in the laboratory at Montevideo, Uruguay, from material sent him from Peru. A few specimens of a hyperparasite identified as *Perilampus* sp.[5], possibly males of *P. paraguayensis* Girault, were reared from the puparia received.

Rearing work with the two parasites *Acaulona peruviana* and *Hyalomya chilensis* was started on receipt of the first shipments. The flies were placed with various-stage nymphs and adults of *Dysdercus andreae and D. sanguinarius*. The adults of *H. chilensis* showed little or no interest, and no attempts at oviposition were noted. The *A. peruviana* flies were actively interested when placed with nymphs and adults of both species of *Dysdercus* and oviposited readily. Mating of both parasite species took place readily in various types of cloth cages when placed in medium to strong light.

Although oviposition by *Acaulona peruviana* took place rapidly, it was apparent from rearing results and dissections of host material that many times the female fly failed to deposit an egg and never did unless the period of oviposition lasted from 5 to 10 seconds. The flies definitely preferred the smaller species of stainer, *Dysdercus andreae*, to the larger species *D. sanguinarius*, although some oviposition took place and material was reared from the latter. Best rearing results were obtained from the use of third-stage nymphs, but considerable difficulty in rearing the parasitized nymphs in the laboratory was

[3] Determined by D. C. Hall, Bureau of Entomology and Plant Quarantine.
[4] Determined by P. A. Berry, Bureau of Entomology and Plant Quarantine.
[5] Determined by A. B. Gahan, Bureau of Entomology and Plant Quarantine.

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experienced and a high mortality generally resulted. The highest percentage of flies reared from any given lot of material was 15.2, although the average was much lower, and the stock was eventually lost in November.

Liberations of *Acaulona peruviana* and *Hyalomya chilensis* were made from both imported and reared stocks in various sections of the island, particularly in those areas devoted to the growing of cotton. The only liberations of *H. chilensis* were from imported material, as follows: At Isabela, 60 in July and 27 in September; at Guayanilla, 50 in October. Liberations of *A. peruviana* were: At Isabela, 603 in September and October; at Guayanilla, 303 in July and October.

Collections of cotton stainers (*Dysdercus andreae* and *D. ruficollis*) were made at Guayanilla and Isabela during May. Two specimens of *Acaulona peruviana* were reared from the Guayanilla collection, and while the percentage of parasitization was extremely low, it did indicate possible establishment of the species.

The rearing of parasites of the sugarcane borer (*Diatraea saccharalis* (F.)) was discontinued in October. Because of increased crop restrictions placed on sugar growers and the necessity of economies on their part, it was impossible for those cooperating in the parasite-rearing program to continue their collections of borer material. We wish to take this opportunity to thank all of those growers in Puerto Rico who have cooperated in this program.

During the months of July to October, inclusive, a total of 807 sugarcane borers were inoculated with larvae of the São Paulo strain of the Amazon fly (*Metagonistylum minense* Towns.). The emergence of adult flies was 379, a percentage of 46.9. Liberations of this strain made at Mayaguez numbered 130 during August, 95 in September, and 60 in October, and at Hormigueros 27 in November.

In collections of sugarcane borers made during the year the Amazon fly was recovered in two localities, the San Germán Valley section and the south coast in the vicinity of Santa Isabel. Both strains are known to be established in various sections of the island. The percentage of parasitization continued to be low, in no case exceeding 1 percent in collections of borers taken from sugarcane; many of the fields were negative. In a small collection of 30 borers taken from field corn at Hormigueros, in the San Germán Valley, a single specimen of the Amazon strain was recovered. The results with this species have been poor thus far, and while the parasite has appeared to maintain itself, it has not exerted any appreciable degree of control of its host.

During July to October, inclusive, 2,216 sugarcane borers were inoculated with larvae of *Paratheresia diatraeae* (Brèthes), another introduced fly parasite of this pest. The emergence of parasites reared from these borers totaled 1,092, a percentage of 49.3.

During January and February, 5 shipments of *P. diatraeae* were received from São Paulo, Brazil, through the cooperation of the Bureau of Entomology and Plant Quarantine. Of the 20,744 puparia received, 2,850 flies emerged, this poor emergence being due largely to heavy hyperparasitization of the puparia. Taking particular care to mate all the *P. diatraeae* females, liberations were made at San Sebastian and Hormigueros, totaling 525 and 1,670 adults, respectively, during January and February.

Liberations of laboratory-reared *P. diatraeae* were continued at Fajardo, where 527 adults were released during July, August, and September. At Mayaguez 60 adults were liberated in October, and at Hormigueros 151 in November.

In addition to the *P. diatraeae* received from São Paulo there was obtained also material of 2 hymenopterous parasites, *Bassus stigmaterus* (Cress.) and *Ipobracon amabilis* (Brèthes). Liberations of 27 and 57 adults, respectively, of these two species were made at Hormigueros.

A shipment of 230 larvae of a coccinellid scale predator, *Azya* sp., was received from Campinas, Brazil, through the Bureau of Entomology and Plant Quarantine. The material arrived in poor condition, and from the larvae and pupae received there emerged only 26 adults, many of which were malformed. A number of unidentified hyperparasites also were reared from these larvae. The adult predators were placed in a cloth cage enclosing leaves of a coffee plant heavily infested with the green scale (*Coccus viridis* (Green)) but no reproduction was noted, and after 20 days 6 adults which were still alive were liberated at Mayaguez.

Many of the scale predators introduced during past years have continued effectively to reduce both the coconut scale (*Aspidiotus destructor* Sign.) and the bamboo scales *Asterolecanium bambusae* (Bdv.) and *A. miliaris* (Bdv.), and are found feeding frequently on other scales in many sections of the island. The three predators most frequently encountered are *Egius platycephalus* Muls., *Chilocorus cacti* L., and *Pentilia castanea* Muls. *E. platycephalus* has been particularly effective against the bamboo scales. This species has been able to maintain itself under conditions of very light host population and to do an excellent job of cleaning up all available scales before leaving in search of another infestation.

The aphid predator *Coelophora inaequalis* (F.) frequently was found in large numbers feeding on the yellow sugarcane aphid (*Sipha flava* (Forbes). While this coccinellid had been found previously feeding on various aphids, particularly those infesting ornamental plants such as hibiscus, it was not until this year that it was seen in large numbers feeding on the sugarcane aphid.

The station continued the policy of distributing on request colonies of established parasites and predators to other Latin American countries. On July 25 a shipment of 17 mated females of *Metagonistylum minense* was sent to the Government of Guadaloupe. On June 3 a shipment of coccinellids consisting of 500 adults of *Cycloneda sanguinea* (L.) var. *limbifer* Csy. and 475 adults of *Coelophora inaequalis*, both aphid predators, were sent to the Minister of Agriculture of Guatemala.

CHEMISTRY

Laboratory Studies: José O. Carrero.

Previous reports mentioned the preparation of orange wine and the potentialities of a commercial wine industry in Puerto Rico. In the manufacture of wines on a commercial scale, there would be considerable residue left after the juice had been pressed and, in addition, some which settles out during the fermentation process. According to the literature such residues, dried and stabilized, are often used

as cattle feed. In the present work it was found that drying in ovens at atmospheric pressure or under vacuum was the best method. The material used included only the crushed cell material which contained some juices, the white outside rind of the fruit, and the seeds, but did not include the colored peel which contains the orange oils. This outer peel might also be used as cattle feed, but it would have greater value in marmalades and preserves or for extraction of the orange oil.

The jack bean (*Canavalia ensiformis* (L.) DC.) has been recommended widely in the Tropics as a soil-building crop. It produces a rather large bean which might have some value as food for human beings or stock, but it has been suspected to contain hydrocyanic acid. However, four qualitative colorimetric tests, using picric acid and chloroform, failed to reveal the presence of hydrocyanic acid either in the mature dried beans or in the fully developed fresh beans.

In a feeding test in which guinea pigs were used as experimental animals, no adverse results were obtained. The diet of the animals was first stabilized, using a mixture of green malojillo grass (*Panicum barbinode* Trin.) and bucare leaves (*Erythrina berteroana* Urban), in order to determine the normal food consumption of the animals. After 20 days the normal diet was reduced to half and supplemented on a dry-weight basis with an equal weight of jack beans of three stages of maturity—immature fresh beans, fully developed fresh beans, and fully developed dry beans. While at first the animals were reluctant to eat the material provided, they soon consumed the amount given them, and throughout the test their appearance, general behavior, and tendency to maintain weight were not affected.

Avocado Oil Studies: Howard T. Love.

Avocados are abundant throughout the American Tropics, but little commercial use has been made of them except as fresh green fruit. The oil of avocados contains appreciable quantities of vitamins A, D, and E and is said to have a high digestibility coefficient. These facts indicate that avocado oil would prove to be a desirable salad and cooking oil in those countries where avocados are produced abundantly and cheaply.

According to the literature, the edible portion of the fruit contains the following constituents: Water 60 to 85 percent, oil 5 to 30, proteins 1 to 3, carbohydrates 5 to 8, minerals 1 to 2, and crude fiber 2 to 7 percent, depending upon the variety. After removal of the greater portion of the water and oil in the extraction process the other constituents are five to eight times more concentrated in the remaining cake than in the unprocessed fruit. This cake would therefore be valuable as a stock feed. With the prevailing shortage of vegetable fats and oils the use of avocado oil as a food and of the cake as a stock feed should have definite possibilities.

A limited amount of avocado oil is used in the cosmetic industry, where, because of its high skin-penetrating power and its ability to form fine emulsions readily, it is highly recommended. The present methods of preparing the oil for this use consist of slicing and drying the fleshy portion of the fruit and then extracting the oil by hydraulic pressure or with organic solvents, such as petroleum ether, ethyl ether, or benzene. Drying increases the cost of production, but it is

not possible to extract the oil from undried fruit because of the high water content. Boiling the pulp with water, even under considerable pressure, releases the oil very slowly and gives poor yields, but freezing releases the oil so that it becomes available to organic solvents. This latter change is probably a result of two things, the dehydration of the cells containing the oil and a rupture of the cell walls. On the basis of this assumption a chemical treatment was sought that would produce the same results. Aluminum chloride and zinc chloride were tried and both gave satisfactory results. However, another method, using lime, was much cheaper and more practical. When treated with lime the pulp of Spinks avocados, known to contain 15.3 percent of oil as determined by the method of the Association of Official Agricultural Chemists, gave the following percentage yield on the basis of total oil: Pressing 90.0 percent, water flotation 82.3 percent, and petroleum extraction by mechanical mixing 96.8 percent.

When as little as 0.5 percent of lime, slaked or unslaked, was mixed with the fresh pulp which had been mashed and pressed through a fine sieve, the oil was released and the pulp set after standing a short time, so that the oil could be expressed in a hydraulic filter press, extracted with organic solvents by mechanical mixing, or obtained by floating off with water. Slightly higher concentrations than 0.5 percent gave a product that could be more readily handled in the press. Avocado pulp treated in this way yielded a clear, golden-yellow oil. This was bleached to a clear water-white oil by extended heating at 100° C. or by exposure to bright sunlight for several days. The latter treatment resulted in the development of rancidity, and some difficulty was experienced in removing the rancid principles by the usual caustic treatment. It is probable that the vitamin A content of the oil was materially reduced, if not entirely destroyed, by the bleaching treatments.

When the lime-treated pulp was extracted with petroleum ether or ethyl ether in a mechanical mixer the oil obtained was a clear green color. The intensity of the green color was influenced by the solvent used and by the length of time the lime-treated pulp was allowed to stand before extraction.

If use is to be made of the cake as a stock feed, the initial concentration of lime added to the pulp should be kept as low as possible, since a 0.5-percent concentration of lime in the pulp becomes 4 or 5 percent in the pressed cake. No extensive experiments have been carried out on the expressed cake obtained from the lime treatment, but it is known that stock will eat the cake provided the lime concentration is kept low.

AGRICULTURAL ENGINEERING

Miscellaneous: Barton C. Reynolds.

The agricultural engineer was on leave for the first 3 months of the fiscal year and resigned at the end of this time. The new appointee reported for duty in April 1942.

The new laboratory wing which was constructed in conjunction with the W. P. A. was completed during the year and all of the laboratory equipment installed. The N. Y. A. cooperated with the station in the construction of the laboratory tables and benches. The wing is now completely occupied, four of the laboratories being utilized by the station chemists and three of the other rooms as office space.

The removal of a number of the chemists to the new wing was followed by a complete renovation of the chemistry laboratory in the main building for the use of the general station chemist. New installations were made throughout.

The floors of two of the offices of the main building were covered with tile and completely renovated. Minor repairs were made to the other station buildings and property.

ESSENTIAL OILS

Production Studies: José E. Natal Colón.

The seeds of musk mallow (*Abelmoschus moschatus* Medic.) yield an essential oil which is used as a fixative in perfumes. An experiment conducted with a view to finding a method of hastening germination of the seed of this species, supplementing that noted in the report of the station for 1938, showed that scarification was hastened by soaking in concentrated sulfuric acid for periods of less than 1 hour. There was a constant increase in scarified and germinated seeds following soaking in acid from 5 minutes up to 45 minutes. Soaking longer than 45 minutes decreased germination, which indicated that for best results the acid treatment should not be continued beyond this period.

Processing Studies: Noemí G. Arrillaga, Merriam A. Jones, and José E. Natal Colón.

The usual practice of preparing lemon grass for experimental distillation has been to pass it through a fodder cutter that cuts ¼-inch pieces, and this method has resulted in a better yield of oil than that obtained from distillation of whole grass. Since it was thought that further comminution might give a better yield of oil, an experiment to compare pieces thus cut with material finely shredded by passing through a hammer mill was carried out. The best results were obtained from the grass cut in ¼-inch pieces. One apparent reason for the difference was the fact that the fine particles of the milled grass became packed and were thus not completely exposed to the action of the steam.

In the harvesting of lemon grass for distillation it has sometimes been the practice to remove the dry material, that is, those leaves and stalks that have ceased to function in the economy of the plant and have died and dried naturally before the grass was harvested. A large sample of this dry, dead grass, chopped and distilled by the usual method, yielded 0.3 percent of oil of good quality and a high citral content. Although this yield was not so high as that obtained from samples of fresh green grass, it was sufficiently good to indicate that such portions of field-run lemon grass should be included in commercial distillations, thus avoiding cleaning and resulting in an increase in the amount of oil produced per acre.

Some plants bearing essential oil yield more oil when dried prior to distillation than when distilled in the fresh state. An experiment with lemon grass, in which the grass was dried and stacked for a period up to 90 days showed, however, a decreasing yield of oil. When distillations were made at the time the grass was cut and also at regular intervals after drying and stacking, the successive distillations showed a continuous drop in the yield of oil as well as in the citral content. The results indicate that lemon grass should not be dried and stacked after cutting except in cases where the value of the oil

is such that it would be economically feasible to lose oil in order to save on transportation costs.

Data on the commercial distillation of lemon grass were obtained from experiments with two commercial stills, one a direct-heat type and the other a steam type, and the station pilot stills in which the immersion water was heated by open steam coils. Approximations of fuel consumption indicated that the steam still was the most efficient in the use of fuel at high rates of distillation, but at low rates the steam type and direct-heat type were about equally efficient.

On the basis of the ratio of oil recovered to water distilled, the rate of distillation, and the time required to complete the processing, the pilot still gave the most rapid distillation. This was due to the small proportion of charge to rate of distillation. The commercial steam still was more efficient than the direct-heat still, which required long periods of distillation as well as preheating.

The water fraction of any distillate usually contains a small quantity of oil. An immersion distillation with lemon grass using this cohobated water gave a good yield of oil, but the oil-water ratios were excessively low and the distillation time was extremely long. It would appear from the data obtained that a high yield of oil and a high rate of entrainment could be obtained more readily by improving the receiver rather than by resorting to cohobation.

The operation data obtained with the two commercial stills indicated that with a 10-horsepower boiler and two 500-pound stillpots 2 tons of lemon grass could be processed per day. The fuel consumed would be about one-half ton of wood, and the labor involved in distillation would be 2 man-days. Valuing the fresh grass at $1 per ton to cover planting and harvesting, it was estimated that the oil produced would cost 50 cents per pound under conditions of normal distillation. Adding 10 cents per pound to amortize the investment of $3,000 for a still over a period of 10 years would bring the total cost to 60 cents per pound. The investment could be reduced if direct-heat stills were used, but the increased fuel cost and labor, on the basis of the data obtained, would increase the cost of the oil for this type of distillation.

Chemical Studies: Noemí G. Arrillaga.

During the past season there was another opportunity to obtain further information on the extraction of an absolute from coffee flowers. Approximately 100 pounds of flowers from the station plantings were utilized in various experiments and in the preparation of absolute. Records kept on the picking of the flowers showed that they could be obtained at the rate of about 1 pound per man-hour. The average extraction of oil is about 0.5 percent. On this basis, if the absolute commands a price commensurate with other flower absolutes, the product should have definite commercial possibilities.

In an experiment made to compare different methods of extraction and the efficiency of different types of apparatus for the extraction of coffee-flower absolute, it was found that extraction with petroleum ether by use of percolators or in Soxhlet extractors gave the highest extraction, averaging slightly over 0.5 percent. Ethyl ether and acetone were also tried. While petroleum ether gave a slightly higher yield of absolute than ethyl ether, the latter gave a highly satisfactory product. Acetone was entirely unsatisfactory. Extraction by the

enflourage method, using liquid vaseline as the nonvolatile solvent, was also unsatisfactory, yielding only 0.2 percent of absolute.

A comparison of the flowers of the West Indian and introduced varieties of coffee, using the foregoing types of extraction, indicated that the flowers of the West Indian variety gave an absolute of slightly stronger aroma than any of the others.

Since there is a possibility that coffee flowers contain enzymatic substances which affect the yield of oil, as is the case with jasmine and tuberose, an experiment was carried out to test the pretreatment of coffee blossoms to make the oil more available either by inducing enzyme action or by bringing about a physical rupturing of the cell walls. Three 1-pound samples of coffee blossoms were subjected to different treatments, (1) 20-pound pressure, (2) dehydration over calcium chloride for 24 hours, and (3) freezing at a temperature of −2° C. for 24 hours, and a fourth received no treatment. All of the samples were then extracted with petroleum ether for 24 hours. The flowers subjected to pressure and desiccation gave considerably lower yields. All of the treatments produced an absolute of good aroma. While freezing did not significantly increase the yield, it offers a possible method for storing or holding the flowers for short periods of time after packing.

Chinabox orange-jasmine (*Murraya exotica* L.) is a shrub or small tree which bears highly fragrant, white flowers. The absolute obtained by petroleum ether extraction from flowers of this plant had a greenish color and a very pleasant, strong aroma resembling jasmine and neroli. An experiment was conducted to determine the feasibility of using petroleum ether for the extraction of oil from successive batches of flowers. Five successive extractions gave a slightly higher yield of oil and was more economical of solvent, but the time of processing was slightly longer.

VANILLA

Production Studies: Ernesto Hernández Medina.

The adverse effect of excessive sunlight on the vigor and growth of vanilla plants is well known to anyone who has attempted to grow this commercial orchid. In the fall of 1940 an experiment consisting of 4 replications of 30 plants each was laid out in Catalina clay soil to determine the effect of 4 different degrees of light on growth. The vines were planted at the base of nonliving support stakes, using the usual mulching practices. Bamboo laths appropriately spaced overhead and on the sides provided varying degrees of shade. Four intensities of sunlight—full, two-thirds, one-half, and one-third—were tested. At the end of 15 months it was clear that the amount of shade provided for vanilla was extremely important to vigorous growth and a healthy condition of the vines. Readings taken during the first year showed that root formation was highly superior in those treatments in which at least one-half of the sunlight was excluded. The amount of stem rotting was recorded every 3 months, and at the end of 15 months the percentage of seed pieces found rotted under full sunlight was 92.1, under two-thirds sunlight 44.3, under one-half sunlight 7.7, and under one-third sunlight 7.1. The average stem growth for the same period was 5.89, 16.17, 22.67, and 23.94 feet per plant, respectively, and the percentage of healthy plants remaining at the end of the period was 32.5, 84.2, 98.3, and 96.6, respectively.

An indication of the health and vigor of the vines was obtained also from the number of 8-node cuttings (142, 713, 975, and 963) produced as a result of the various treatments, ranging from full to one-third sunlight. The respective weights of the cuttings were 26.75, 201, 344, and 366 pounds per treatment.

Marked variations in the development of the vines were noted throughout the experiment. Those under full and two-thirds sunlight tended to be yellow-green in color and had comparatively short, thin internodes, while vines grown under one-half and one-third sunlight were of a darker green color and had longer and thicker internodes.

The highly significant differences obtained between treatments with respect to root formation, seed-piece rotting, stem growth, and healthy plants are direct evidence that vanilla needs appropriate shade, from one-half to one-third sunlight, for its best development.

Results of experiments in progress confirmed previous observations on the need for good soil aeration and drainage to minimize the fusarium root rot disease which is common in many parts of the island, particularly on heavy soils. In a soil-texture alteration experiment, in which vanilla was planted on beds of gravel 2 feet square and 1 foot deep, artificially constructed by filling well-drained holes dug in Catalina clay soil, it was found at the end of 2 years that there were 30 percent more healthy plants when the vines were planted on gravel than when they were planted on Catalina clay.

The dead, fibrous, adventitious root mass of certain tree ferns, *Cyathea* spp., found growing abundantly in the mountainous regions of Puerto Rico, has been shown to fulfill the requirement of good drainage necessary in the growing of ornamental orchids. It therefore seemed desirable to test this material as a mulch for vanilla, both alone and in combination with the usual leaf mulch. On a lateritic soil similar to Nipe clay the amount of roots produced, the number of seed pieces rotting, and the vegetative growth made were nearly equal in all treatments, and no significant differences could be noted between them.

Two promising support trees for growing vanilla are common cashew (*Anacardium occidentale* L.) and *Bauhinia reticulata* DC. As these two species are most conveniently propagated by seeds, experiments were undertaken to find a means to hasten germination. Seeds of *Bauhinia* that have been harvested for a few months turn black in color and, like those of cashew, germinate very slowly. Soaking the seeds in concentrated sulfuric acid followed by rapid, thorough flushing with water hastened germination considerably. The best treatment found for the cashew seed was soaking in sulfuric acid for 30 minutes and for the *Bauhinia* seed a similar soaking but for a period of only 5 minutes. Longer periods of soaking apparently caused injury and lessened germination.

Processing: Francisca E. Arana.

Studies on some of the chemical changes which take place during the curing of vanilla beans were completed during the year.

The formation of vanillin, the essential flavoring quality of vanilla beans, is known to result from the activity during curing of a β-glucosidase which catalyzes the hydrolysis of the vanillin-containing

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glucoside present in the green bean. Experiments conducted to determine the distribution of glucovanillin in fresh beans showed that this glucoside was found throughout the pod but was more highly concentrated in the central than in the outer portion. The most interesting results of this study showed that glucovanillin was present in largest quantities in the blossom end of the pod and decreased gradually toward the stem end. This accounts for the usual formation of vanillin crystals in only the lower two-thirds of cured beans.

Studies on the hydrolysis of glucovanillin in uncured beans at different stages of maturity showed that only a small fraction of the glucovanillin was hydrolyzed in uncured, wholly green beans and in blossom-end-yellow beans, whereas in chocolate-colored beans, which had undergone a natural ripening process, the glucoside was found to be already hydrolyzed.

By preparing aqueous extracts of mature blossom-end-yellow vanilla beans and incubating them with glucovanillin for a period of 6 days, the presence of a β-glucosidase was determined. The phenol value, which was used as an index of the amount of enzymatic hydrolysis due to the action of this crude enzyme, was 7.2 percent after proper corrections for the phenol value of the glucovanillin and the enzyme had been made. Upon separating this enzyme from the uncured beans by a modification of the process used for the extraction of emulsin from sweet almonds (*11*, *p. 186*), the phenol value due to the action of the separated enzyme solution was 0.95 percent in one sample and 1.56 percent in another. Thus, while the activity of the separated enzyme was not high it was nevertheless definite.

Enzyme extracts prepared from the outer fleshy portion of the bean and incubated with glucovanillin gave a phenol value of 6.3, while those of the central portion incubated in the same way showed no evidence of an active β-glucosidase. Extracts made from whole, entirely green beans showed the presence of a very slightly active β-glucosidase, whereas blossom-end-yellow beans showed considerably greater phenol value, indicating that the activity of the enzyme increased with ripening.

In an experiment using entirely green beans it was found that the β-glucosidase was only slightly active after the initial killing procedure and during the sweating period. This unquestionably is an explanation of curing observations that vanilla beans in the green state do not develop a desirable aroma and a high vanillin content.

In the annual report for 1941 experiments were described regarding losses in weight during vanilla processing. It was shown that the loss in weight other than that due to loss of moisture was not significant, regardless of the curing procedure used. This loss in weight can be calculated provided the moisture content of the fresh beans is known. The moisture content of the fresh beans was found to decrease with the maturity of the beans. Whole mature beans that were entirely green had a slightly higher moisture content than those with the blossom ends yellow. The range of moisture content determined for such beans was from 78.5 to 81.5 percent. For practical purposes, therefore, it may be assumed that whole mature beans have a moisture content of 80 percent.

In the curing process the original or fresh weight of the beans is reduced to obtain a final product of a given moisture content. This reduction can be controlled up to the time of conditioning; further

reduction depends on the number of times the conditioning box has to be opened and the length of time necessary to examine and wipe the beans free of molds. According to typical data the loss during conditioning can be taken as 4 to 7 percent on the fresh basis when a final moisture content of 30 to 40 percent on the cured basis is desired, and 1 to 3 percent when 20 to 30 percent moisture is desired.

To determine the percentage of the original fresh weight to which any lot of beans must be reduced to obtain a known final moisture content, divide the percentage of dry matter of the fresh beans, estimated at 20, by the percentage of dry matter desired in the final product and multiply this by 100. To this result must be added the expected loss during conditioning, which is from 1 to 7 percent, as noted above, to give the percentage of the original fresh weight to which the beans must be reduced before conditioning.

BAMBOO

Propagation: Atherton Lee, Armando Arroyo, and Claud Horn.

The expansion of the bamboo-propagation work of the station was considerably curtailed because of labor shortages and the need for emphasis on other projects of more importance to the war effort.

Plants of Ecuadoran and Canal Zone bamboos of the genus *Guadua*, P. I. Nos. 132894 and 132895, were received through the Division of Plant Exploration and Introduction of the Bureau of Plant Industry. These introductions of *Guadua* are the first of this genus to be grown at the station.

Permanent plantings of various introduced species of bamboo have been maintained during the year and have aided in the control of soil erosion on steep hillsides of the station property. In addition to their economic value, these bamboos add considerably to the beauty of the station grounds and require a minimum amount of maintenance. A total of 664 plants of 5 different species of introduced bamboos were distributed during the year.

Utilization: Howard T. Love.

Recent work (*2*, *3*) by the United States Department of Agriculture Forest Products Laboratory, Madison, Wis., on methods of making wood plastic suggested that two such processes might be applied to bamboo. The urea-impregnation process, which yields a thermoplastic wood, and the urea-formaldehyde-impregnation process, which yields a thermosetting wood, were both tried. Since no special bending equipment was available the tests were necessarily confined to strips and culms of small diameters. *Bambusa tulda* Roxb., a hollow species, and *Dendrocalamus strictus* (Roxb.) Nees., which is solid, were used.

The urea treatment applied consisted in soaking the wood in a saturated solution of urea until wet throughout, heating to 100° C. in the urea solution, and cooling and drying after bending to the desired shape. Strips of bamboo thus treated became pliable and could be bent into a circle. Hollow bamboo also became pliable, but the inner wall collapsed when bent through an arc of short radius. Solid bamboo, ½ to ¾ inch in diameter, was bent through an arc of 90° or more on a 4-inch radius. Neither the strips nor the solid bamboo retained their bent form well; both had a tendency to straighten

somewhat after cooling and drying. When the curvature of the bent strips was increased they did not snap back into place but regained their original shape slowly. They lost most of their flexibility or springiness, an effect not so noticeable in the more rigid, solid bamboo.

This treatment appeared to have no advantage over heat bending when applied to strips or whole bamboo pieces of small diameter. With larger diameters (1 to 3 inches) of solid bamboo it might be advantageous, since pieces of this size are very rigid and it would be desirable to be able to bend them in furniture construction.

Strips of bamboo ½ to 1 inch wide, cut from tubular and solid bamboo, and tips of culms ½ to ¾ inch in diameter were treated with urea-formaldehyde solution made up according to the formula of the Forest Products Laboratory (*3, p. 85*). After treatment and heating in a boiling urea solution the strips and solid pieces could be easily bent and they retained their shape after cooling and drying, whereupon the wood became rigid and lost the flexibility normally found in bamboo. The experiment indicated that this process would greatly increase the usefulness of bamboo in furniture where bent or rigid construction was desirable. The present difficulty of obtaining chemicals and necessary equipment has temporarily prevented the testing of these processes on bamboo of large diameter.

Toward the end of the fiscal year Allan Gould, engaged by the Puerto Rico Housing Authority and later by the Office of the Coordinator of Inter-American Affairs, carried out cooperative work with the station on the design and construction of furniture made of bamboo. During this short period a number of new and useful pieces were developed that were pleasing and mechanically strong in design and could be readily constructed.

SUGARCANE

Variety Trials: Ernesto Hernández Medina.

In previous annual reports attention was called to the outstanding performance of some of the Mayaguez seedling varieties of sugarcane developed by the station and distributed to interested growers for trial throughout the island. During the past season additional information has been accumulated on these varieties in relation to the first-ratoon crop. An experiment planted on Santa Isabel medium heavy clay and harvested in May 1942 showed that the Mayaguez varieties 275, 314, 317, 326, 340, 341, and 345 outyielded the district standard B. H. 10 (12) by a minimum of 2.22 tons to a maximum of 24.71 tons of cane per acre and by 0.31 to 2.21 tons of sugar per acre. M–326 was the outstanding cane in the first-ratoon crop, being highly superior in yield of cane and sugar produced per acre. It also averaged the largest tonnage of cane per acre for the plant and first-ratoon crops, being slightly ahead of M–341 and M–317 in this respect. M–317 averaged more tons of sugar per acre than any other variety in both crops but only slightly more than M–341.

In another experiment on Coloso silty clay loam, in which three Mayaguez varieties, 275, 317, and 338, were tested against the district standard P. O. J. 2878, it was found that only one variety, M–275, was superior in cane tonnage and in sugar yield to P. O. J. 2878 in the first-ratoon crop; however, the differences were not statistically significant. The average quantities of cane and sugar produced by the

different varieties for both the plant and first-ratoon crops showed that M–275 yielded more cane per acre than any other variety, while M–338 was superior to the other varieties in sugar yield per acre, but in no case were these differences significant.

In a gran-cultura planting on a soil known as Toa silt loam, five Mayaguez varieties, 275, 317, 338, 344, and 345, were tested against P. O. J. 2878, the standard variety for the district, and also against P. R. 900. Three Mayaguez varieties, 275, 317, and 344, outyielded P. O. J. 2878 in cane tonnage and two, 275 and 344, in sugar per acre, while all varieties outyielded P. R. 900 in both cane tonnage and sugar per acre. Statistically, M–275 was superior in cane tonnage to all other varieties in a highly significant degree, outyielding the district standard by 9.26 tons of cane per acre; it also surpassed the district standard by 0.56 ton of sugar per acre. M–275 yielded 14.10 percent more cane and 7.49 percent more sugar, and M–344 produced 6.82 percent more cane and 4.95 percent more sugar per acre than the district standard P. O. J. 2878.

During the year 17,363 seed pieces of 18 Mayaguez varieties were distributed to sugarcane growers of the island.

COFFEE

Variety Trials: In cooperation with Jaime Guiscafré Arrillaga and Luis Gómez, University of Puerto Rico Agricultural Experiment Station.

In the coffee experiment being conducted in cooperation with the experiment station of the University of Puerto Rico, the Columnaris variety of *Coffea arabica* L. outyielded the West Indian variety almost 3 to 1, thus maintaining its lead by a considerable margin during the past 8 years. The respective yields per acre for 1941 were 1,563 and 543 pounds. The 8-year average of 1,249 pounds of Columnaris and 642 pounds of West Indian are over 8 and 4 times, respectively, the average production of 150 pounds per acre for the island.

Studies of the number of flowers produced and the percentage reaching maturity were again conducted on both varieties during 1941. The blossom losses this year of the Columnaris were 51.8 percent, in comparison to the 63.7 percent for West Indian.

PUBLICATIONS

The progress of the work of the station during the past year was summarized in quarterly reports instead of in monthly reports as in former years. These reports, totaling 74 pages, were mimeographed for interoffice circulation, 66 copies of each of the 4 issues being sent to offices in the Department of Agriculture and elsewhere, on request, to individuals maintaining a professional interest in the current work of the station.

The English edition of the annual report for the fiscal year 1940 was issued in June, and the Spanish translation of the report for 1939 was issued in April. Both editions had a wide circulation, not only among agricultural and educational institutions throughout the world, but also among farmers and others in the continental United States, the Canal Zone, Hawaii, Puerto Rico, and the Virgin Islands. The mailing list to 47 foreign countries included 389 requests for the

English edition; in 18 of these countries 83 requests were for the Spanish edition. Local interest in the work of the station, especially among the farmers of Puerto Rico, was evidenced in an increasing number of requests for the Spanish edition.

The bulletin series of the station was increased by the following two publications:

BARTLETT, KENNETH A. The biology of *Metagonistylum minense* Tns., a parasite of the sugarcane borer. Puerto Rico (Mayaguez) Agr. Expt. Sta. Bul. 40, 20 pp., illus. 1941.

MCALISTER, L. C., MCCUBBIN, W. A., PFAFFMAN, G. A., OWREY, W. T., TAYLOR, H. G., and BERRYHILL, I. W. A study of the adult populations of the West Indian fruitfly in citrus plantations in Puerto Rico. Puerto Rico (Mayaguez) Agr. Expt. Sta. Bul. 41, 16 pp., illus. 1941.

In addition to the above, the following specialized articles were written by workers at the station and published during the year:

ARANA, FRANCISCA E. Vanilla investigations. Rev. de agr. de Puerto Rico 34: 73–78, illus. 1942. (Paper presented at meeting of Puerto Rico chapter of Amer. Soc. Agr. Sci., Mayaguez, Oct. 12, 1941.)

ARRILLAGA, NOEMÍ G. A new perfume oil from coffee flowers. Rev. de Agr. de Puerto Rico 34: 82–84. 1942. (Paper presented at meeting of Puerto Rico chapter of Amer. Soc. Agr. Sci., Mayaguez, Oct. 12, 1941.)

ARRILLAGA, NOEMÍ G., and JONES, MERRIAM A. The use of salt in distilling bay leaves, [I]. Amer. Perfumer and Essential Oil Rev. 43: 29–32, 79, illus. 1941. (Reprint in Spanish, translated by Carmelo Alemar and Efraín Avilés Lojo, appeared in Rev. de Agr. de Puerto Rico 34: 129–137, illus. 1942.)

BAILEY, WALLACE K. Growing USDA–34 sweet corn in Puerto Rico. Rev. de Agr. de Puerto Rico 34: 222–225. 1942.

BALLS, A. K., and ARANA, FRANCISCA E. The curing of vanilla. Indus. and Engin. Chem., Indus. Ed., 33: 1073–1075. 1941. (Reprint in Spanish, translated by Carmelo Alemar and Efraín Avilés Lojo, appeared in Rev. de Agr. de Puerto Rico 34: 167–172. 1942.)

BALLS, ARNOLD K., and ARANA, FRANCISCA E. Recent observations on the curing of vanilla beans in Puerto Rico. Proc. 8th Amer. Sci. Cong. 7: 187–191. 1942. (Paper presented at Eighth Amer. Sci. Cong., Washington, D. C., May 14, 1940.)

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MOORE, RUFUS H. Effect of nutritional levels on the elaboration of rotenone. Rev. de Agr. de Puerto Rico 34: 111–113. 1942. (Paper presented at meeting of Puerto Rico chapter Amer. Soc. Agr. Sci., Mayaguez, Oct. 12, 1941.)

PENNOCK, WILLIAM. La piña en Puerto Rico. Rev. de Agr. de Puerto Rico 33: 521–532, illus. 1941. (Reprint of Pennock, William. [Pineapple cultivation in] Puerto Rico. *In* Coulter, John Wesley. La Piña. Unión Panamer. Pub. Agr. 134–136, pp. 35–53, illus. 1940. Noted in report of this station for 1941.)

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1926. ENZYMES; PROPERTIES, DISTRIBUTION, METHODS AND APPLICATIONS. 364 pp., illus. Baltimore.

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